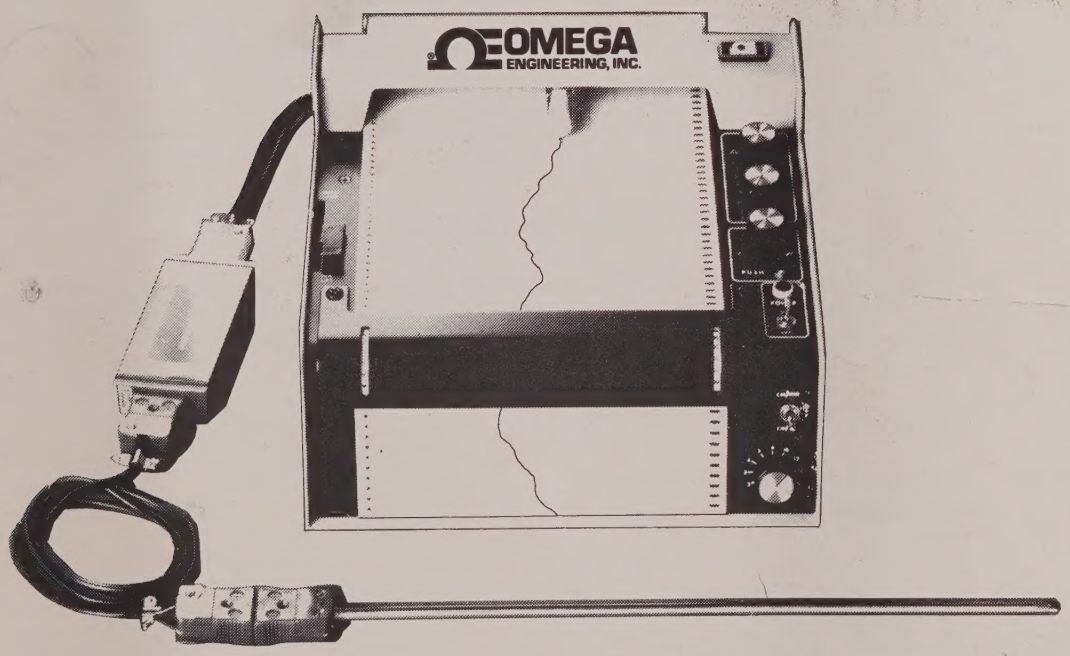
MODEL 156
Strip Chart Recorder



Operator's Manual

OMEGA
ENGINEERING, INC.

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of one (1) year from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive current, heat, moisture, vibration, or misuse. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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Return Requests/Inquiries

Direct all warranty and repair requests/inquiries to OMEGA Customer Service Department, telephone number (203) 359-1660. Before returning any instrument, please contact the OMEGA Customer Service Department to obtain an authorized return (AR) number. The designated AR number should then be marked on the outside of the return package.

To avoid processing delays, also please be sure to include:

1. Returnee's name, address, and phone number.
2. Model and Serial numbers.
3. Repair instructions.

OMEGA® ENGINEERING, INC.

One Omega Drive, Box 4047
Stamford, Connecticut 06907-0047
(203) 359-1660 Telex: 996404 Cable: OMEGA

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SECTION 1 INTRODUCTION

1.1 GENERAL DESCRIPTION

The OMEGA® Model 156 Strip Chart Recorder is a precision, single pen, multi-range recorder which provides an accurate graphic record of input signals, such as dc voltage, current, temperature (thermocouple input) and similar variables.
The recorder operates at speeds of 30 cm/min. to 1 cm/hour, at multiple spans from 1 mV to 10 V dc, and provides ±100% full-scale zero suppression to allow up to two times the input at any range desired. The instrument can be field adjusted for operation from either 115 or 230 V, at 50 or 60 Hz. Chart width is approximately 5" (125 mm).

1.2 FEATURES

- Multiple chart speeds
- Multiple span ranges
- Disposable fiber-tipped pen
- Uses both roll or Z-fold chart paper
- Fully adjustable from baseline-to-baseline (10-100%)
- Works with thermocouples (requires a digital thermometer with analog output or a thermocouple-to-analog converter -- alternatively may use cold-junction compensation unit for non-linear trace)
- Works with infrared sensors having analog output

1.3 OPTIONS

(1) Mechanical Event Marker
When a contact closure is made between terminals 4 and 5 on the terminal strip at the rear panel (see Figure 3-1), a separate solenoid-actuated pen assembly provides a short mark at the left edge of the chart.

(2) Electric Pen Lift

When a contact closure is made between terminals 6 and 7 on the terminal strip at the rear panel (see Figure 3-1), an internal solenoid lifts the recorder pen off the recorder chart.

SECTION 2 INSTALLATION

2.1 UNPACKING

Remove the packing list to check off actual equipment received. If you have any questions on your shipment, please call OMEGA Customer Service Department at (203) 359-1660.

Upon receipt of the shipment, inspect the container and equipment for any signs of damage. Take particular note of any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

NOTE

The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing contents, save packing material and carton in the event reshipment is necessary.

2.2 CHECKING THE FUSE

Check that the proper fuse has been installed on the back panel of the recorder. The instrument is factory wired for either 115 or 230 V ac operation. A 3 AG 0.3A slow-blow fuse is used for 115 V ac operation; a 3 AG 0.15A slow-blow fuse is used with the 200 V ac instrument.

2.3 LOADING THE CHART PAPER (see Figure 2-1.)

1. Use a new roll of paper. Tear each side of paper to form a blunt point at its center.
2. Push the paper supply seat sideways to compress the roller spring. Insert the new roll of paper, making certain that the core of the paper roll sits properly between the right and left-hand paper supply seats.
3. Manually feed the point of the paper under the pen cover until the paper can be pulled across the writing area.
4. Raise the pen lift and paper load lever. Pull the paper forward, over the paper sprockets and under the paper hold down plate.
5. Lower the pen lift and paper load lever to its center position (paper guide plate down, pen carriage up).

2.4 INSTALLING THE RECORDER PEN

1. Set the pen lift and paper load lever to its center position.
2. Remove the pen cap; store it in a safe location.

NOTE

It is advisable to cap the pen when not in use, to prevent the pen from drying out.

3. Slide the pen underneath the spring and into the pen carriage. Push the pen back, until the pen nib collar seats into the V-groove on the pen carriage.
4. Push the pen lift and paper load lever down.

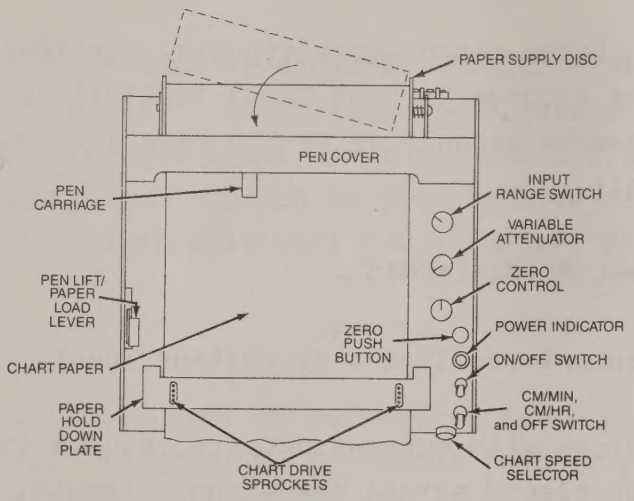


Figure 2-1. Installation Guide

SECTION 3 OPERATION

3.1 POWER REQUIREMENTS

Recorders are shipped ready-to-operate on a nominal voltage of 115 or 230 V ac at 50 or 60 Hz. Conversion can be made from one voltage source to another by setting a switch (see Figure 3-1) on the back panel to its proper position.

3.2 GROUNDING REQUIREMENTS

For best performance, the green (or green and yellow) ground wire from the power cord and the signal source should share a common earth ground.

The green (or green and yellow) wire from the power cord is connected to the recorder ground (chassis); but not to the signal input. If the signal input does not have a third wire in its power cord, or if the instrument is not grounded, connect a wire between the recorder ground (GND) terminal and the chassis of the signal source.

In case of large common-mode signals, particularly 120 Hz, connect the recorder ground (GND) terminal to the source of the common-mode signal, or to the negative recorder input (- terminal).

3.3 INPUT SIGNAL REQUIREMENTS

This instrument requires a dc voltage input.

Signal sources with current outputs require that a shunt resistor be placed across the + and - inputs. Ohm's law may be used to compute the proper value for a given input range. The formula is: $R = \frac{E}{I}$

Where E is the recorder span range selected in volts,
I is the maximum current signal to be recorded in amps, and
R is the resistance of the shunt resistor in ohms.

Input connections are made as follows:

(1) Signal source positive to recorder (+) terminal.
(2) Signal source negative to recorder (-) terminal.

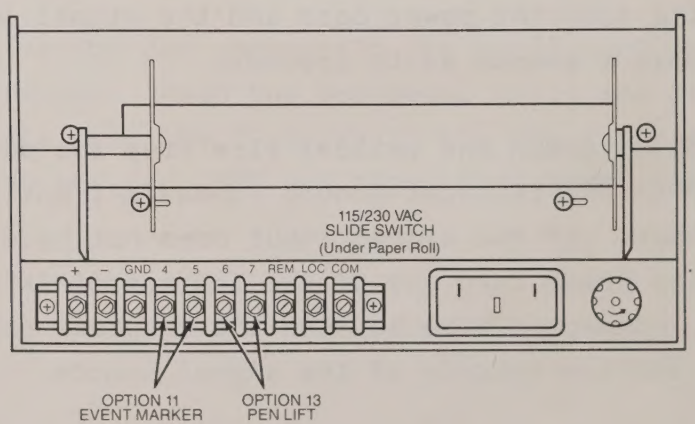


Figure 3-1. Recorder Rear Connections

Right-hand chart zero is standard; positive signals drive the pen to the left. If an opposite presentation is desired, reverse the input leads and use the zero adjust control to position the pen at the opposite side of the chart. Positive signals will now drive the pen to the right.

NOTE

This instrument is calibrated for a right-hand zero. Reversal of the input leads may yield a ±3% full scale error.

3.4 CONTROLS AND INDICATORS

Figure 3-2 and Table 3-1, respectively, illustrate and describe the controls and indicator.

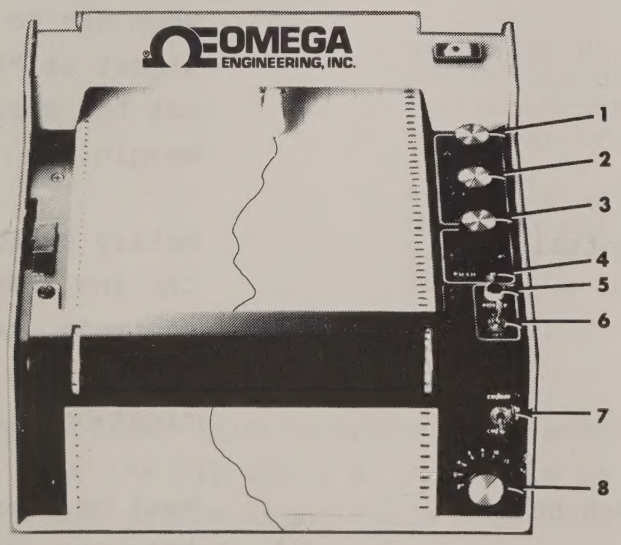


Figure 3-2. Controls and Indicator

TABLE 3-1

MODEL 156 RECORDER CONTROLS AND INDICATOR

ITEM NO.	CONTROL OR INDICATOR	FUNCTION
1	INPUT Switch	Five position rotary selector switch, for input levels: 1 mV, 10 mV, 100 mV, 1 V, 10 V.
2	ATTEN/CAL Control	When ATTEN control is rotated the input signal is increased or decreased to deflect the pen upscale or downscale. This control establishes the full-scale (left-hand) margin. When set to CAL, input signal is "Zeroed-out" to set the zero (right-hand) margin.
3	ZERO control	Rotary switch, used with CAL and ZERO push-button controls, to deflect the pen to zero (sets zero; right-hand margin).
4	ZERO push-button	Must be pressed-in and held, to set zero baseline. This control is used with the ATTEN/CAL and ZERO controls.

TABLE 3-1 (Con't)

ITEM NO.	CONTROL OR INDICATOR	FUNCTION
5	Power Indicator	Illuminates when power is applied.
6	ON/OFF Switch	Two position toggle switch, turns recorder ON and OFF.
7	CM/MIN, CM/HR, and OFF Switch	Three position toggle switch, sets chart speed or turns chart drive motor OFF. When set to CM/MIN, or CM/HR, drives chart at the rate selected by chart speed control (item 8). For example, setting switch to CM/MIN and chart speed control to 5, drives chart at 5 cm per minute.
8	Chart Speed Control	Establishes rate chart is advanced. Used with CM/MIN, CM/HR, and OFF to drive chart a certain distance per minute or per hour. Available settings on this control range from 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, to 30.

3.5 OPERATION

1. Plug the recorder into an appropriate power receptacle.
2. Confirm that the 115/230 V ac switch is set properly.
3. Set the power switch (see Figure 3-2, item 6) to ON.

NOTE

If high accuracy/stability of recordings are required, allow the recorder to warm up for about 30 minutes prior to operation.

4. Set the CM/MIN, CM/HR, and OFF switch (item 7) to OFF.
5. Set the INPUT control (see Figure 3-2, item 1) to the desired range.
6. Set the ATTEN/CAL control (see Figure 3-2, item 2) to position CAL.
7. Press the ZERO push-button (see Figure 3-2, item 4) and hold it in.
8. Rotate the ZERO control (see Figure 3-2, item 3) to zero the recorder pen on the chart paper.
9. Apply an input signal of a known value to the recorder.
10. Move the INPUT control (see Figure 3-2, item 1) to each position in turn (working from lowest to highest) and observe the full-scale pen deflection. When the pen is deflected off-scale (overrange), back off the control one-position, or until the pen is closest to the appropriate full-scale margin, but not off-scale.
11. Set the ATTEN/CAL control (see Figure 3-2, item 2) to ATTEN and adjust full-scale at its appropriate position. Remove the input signal.
12. Set CM/MIN, CM/HR, and OFF control (see Figure 3-2, item 7) to the appropriate rate.
13. Set the chart speed control (see Figure 3-2, item 8) for the appropriate chart speed.

3.6 REMOTE CHART CONTROL

The chart drive can be controlled from a remote location, by a contact closure between terminals REM and LOC on the terminal strip at the rear panel (see Figure 3-1).

3.7 REMOTE CHART PROGRAMMING

The recorder chart drive system can be operated from an external frequency source, such as transistor-transistor logic (TTL) levels.

The chart can be run at rates different from those built into the recorder, by applying a pulse train (Table 3-2) to the REM and the COM terminals on the rear panel terminal strip.

NOTE

The jumper between the REM and the LOC terminals must be removed for programming.

TABLE 3-2
PULSE TRAIN REQUIREMENTS

PULSE STATE	VOLTAGE REQUIREMENTS
0 (Low) State	Voltage: +0.5 V or less
1 (High) State	Voltage: +3 to 10 V, maximum
Minimum Pulse Width:	100 microseconds

Pulse frequencies up to 10 kHz may be used, if the chart speed selector switch is set to limit the actual chart movement speed to 50 cm/min. or less. A 50 cm/min. paper speed can be obtained by applying a 250 Hz external frequency and setting the chart selector switch to position 30 cm/min.

The formula is: Chart Speed: $\frac{F}{150\ Hz} \times S$

Where: F = external frequency in Hz
S = selected chart speed

When the external frequency is set to 150 Hz, the chart drive will run at the speeds marked on the top panel selector switch. If the external frequency is increased or decreased by 10%, the acutal chart speed will be 10% faster or slower than the setting on the panel selector switch.

EXAMPLE

The selector switch is set to 30 cm/min. and the external frequency is set to 165 Hz (a 10% increase). The chart paper will run at a 33 cm/min. rate.

NOTE

Changes of external frequency affects all selector speed rates by the same factor.

The recommended maximum chart speed for start/stop operation is 50 cm/min. If the frequency is "swept" (not start stop), it is possible to run faster than 50 cm/min; however, the sweep rate must be gradual enough to assure accurate mechanical tracking.

OPERATING NOTES

1. Make sure the chart paper holes are properly aligned with sprocket teeth.
2. REM and LOC terminals (see to Figure 3-1) must be jumpered together, unless the remote chart control is used; otherwise, the chart drive will not function.
3. When switching sensitivity ranges, it may be necessary to rezero the pen. To do so, push the zero push-button and readjust the ZERO control. (The ZERO control has no stops at the end of mechanical travel.)
4. The input resistance is high enough so the pen may drift with no connections to the input.
5. If the pen stalls on the chart for a few seconds, the servo system will shut down to protect the motor. The best way to reset the system is to turn the recorder off for about five seconds, and then turn it on. The pen should activate and continue to record normally. If the shutdown resulted from an overrange, the recorder will operate normally as soon as the input signal decreases to a level which is within the selected span range.

SECTION 4 THEORY OF OPERATION

4.1 OPERATING PRINCIPLES

The dc input signal to the recorder is first filtered and then amplified to a level which is less susceptible to noise and interference. This conditioned signal is applied to the servo amplifier, which continuously compares it to a feedback signal developed by the servo potentiometer.

The difference between these two signals is either a positive, or a negative error signal, that is amplified to drive the servo motor in the direction that reduces the error signal to zero.

Since the recorder pen is mechanically coupled to both the servo motor and the servo potentiometer, its position on the chart represents an accurate and continuous record of the input signal (see Figure 4-1).

The ac line voltage is reduced by stepdown transformers and converted to dc by solid state rectifiers and regulators. A stable dc voltage is generated as a reference for the servo potentiometer.

The pen drive mechanism and the servo potentiometer are driven by a dc servo motor, through a gear-driven servo drum assembly. The pen is attached to a drive cable, which is wrapped around--and secured to, the drum. As the drum rotates, the pen is moved across the chart paper for a distance that is proportional to the amount of drum rotation.

In the chart drive system, a crystal oscillator generates pulses that are divided by the logic circuitry. The chart speed switch (see Figure 3-2, item 8) selects the appropriate pulse rate to drive the stepper motor at the desired speed.

NOTE

The crystal frequency is not a function of line frequency; therefore, the chart speeds are completely independent.

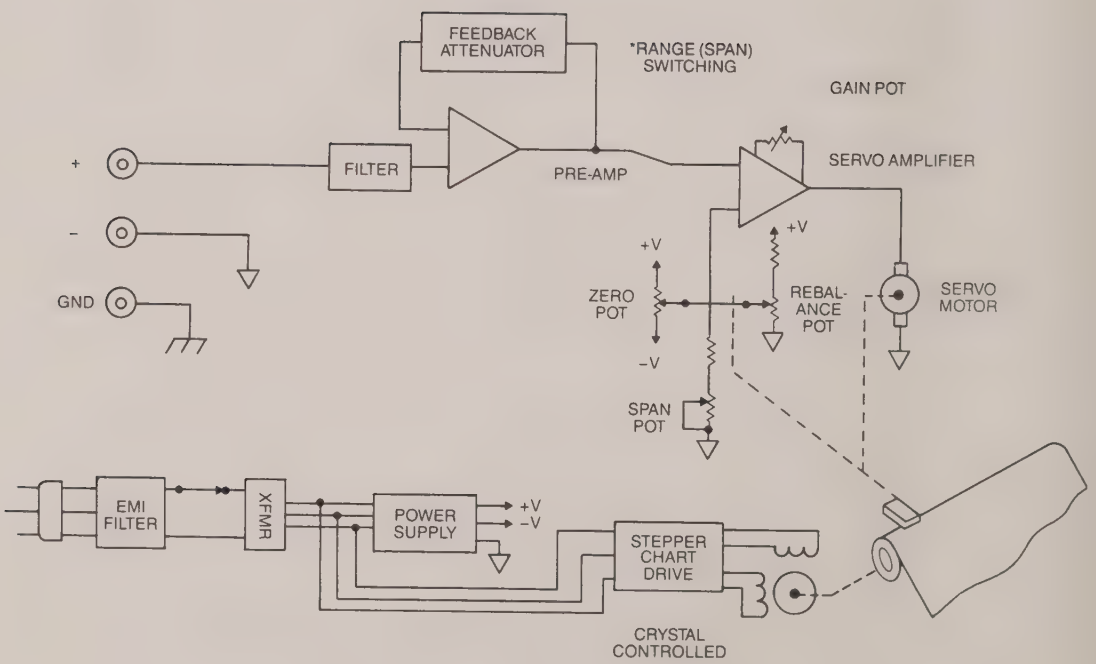


Figure 4-1. Input Signal Block Diagram

SECTION 5 SERVICE INFORMATION

5.1 MAINTENANCE

The OMEGA Model 156 Strip Chart Recorder is a sturdy and long-lasting precision instrument. Nevertheless, a few maintenance procedures will promote optimum performance and help to extend the instrument's life.

5.1.1 Routine Cleaning

Exterior surfaces of the recorder should be cleaned periodically by wiping with a soft cloth slightly dampened with water. Solvents should not be used as they may damage the finish.

5.1.2 Pen Care

Chart paper and pens are carefully matched for optimum writing and minimum bleed. Substitutions could cause improper writing. To prolong pen writing life, keep pen tips covered when not in use.

NOTE

If a pen dries out from being uncapped for a long period of time, it may be revitalized by dipping it in water for a few seconds.

5.1.3 Free Chart Paper Movement

Do not force the paper hold down bracket. This could cause paper binding as it feeds over the sprockets. Firm tension and correct alignment of the paper hold down bracket are required for proper chart paper feed.

5.2 CALIBRATION

The recorder is designed for long, trouble-free operation. However, after periods of long-term use, the recorder sensitivity may degrade and the following calibration procedures may have to be performed.

> WARNING
> Calibration should be performed by a trained and qualified technician. These procedures may expose hazardous voltage.

5.2.1 Gain Adjustment

The gain adjustment controls the servo loop gain or "deadband" of the recorder. It can be reached through the hole in the bottom of the recorder labeled GAIN (see Figure 5-1). If gain is set too high, the pen will "buzz"; if set too low, the pen will be sluggish.

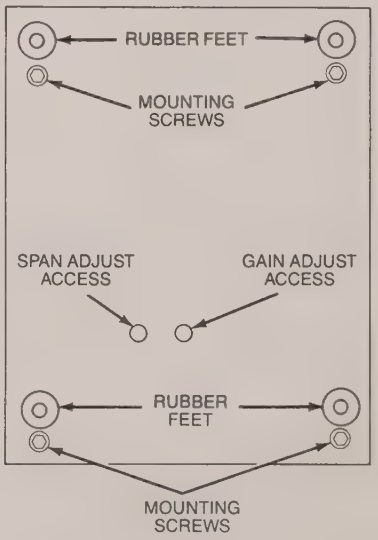


Figure 5-1. Controls on Underside of Recorder

1. Short the (+) and (-) input terminals, and set the pen to center scale by rotating the ZERO control.
2. Rotate the GAIN control clockwise until the pen buzzes. Back off the GAIN control by rotating it counterclockwise until the buzzing stops.
3. Recheck the adjustment by moving the pen over the full scale, using the ZERO control. If the pen buzzes at any point, turn the GAIN control counterclockwise until the buzzing stops.

5.2.2 Zero Offset

The zero offset adjustment, which reduces the zero shift between input spans to a minimum value, requires that the recorder input be switched between a short-circuit and a 50 kilohm resistor.

1. Connect a 50 kilohm resistor across input (+ and -) and use a jumper wire to short the input.

   NOTE

   A PCB offset connector is required for this calibration procedure.
2. Allow the recorder to warm up for about 30 minutes. Remove the cover.
3. Connect the short across the input terminals.
4. Set the INPUT rotary switch to position 10 mV.
5. Use the ZERO control to position the pen at mid-scale.
6. Set the INPUT rotary switch to position 1 mV.
7. Return the pen to the setting established by Step 5 with the use of the E_0 potentiometer in the preamp circuit.
8. Remove the short which was connected in Step 3.
9. Return the pen to the setting established by Step 5 with the use of the I_0 potentiometer in the preamp circuit.
10. Repeat Steps 3 through 9 until minimum pen movement has been achieved.

5.2.3 Span Calibration

This procedure adjusts the recorder so that a calibrated full scale input signal will move the pen up to the full width of the chart.

The first span adjustment can be reached through the hole in the bottom of the recorder marked SPAN (see Figure 5-1). The second span adjustment is not normally necessary. The bottom panel must be removed to gain access to the second span adjustment control.

1. Allow the recorder to warm up for about 30-minutes.
2. Set the recorder to the 1 mV position, and set the signal source to zero output.
3. Carefully align the pen over zero by rotating the ZERO control.
4. Apply a 1 mV dc signal (0.1% accuracy) to the input.
5. Rotate the SPAN control until the pen is at 100%.
6. Check all input spans for proper inputs for 100% $\pm$0.5% deflection. Check recorder zero for all ranges; reset as necessary.

NOTE

If spans for ranges 1 V and 10 V do not deflect to 100% $\pm$0.5%, continue with the following steps:

7. Remove the bottom panel and set the INPUT switch to the 1 V position. Check recorder zero; reset as necessary.
8. Apply a 1 V dc signal 0.1% accuracy to the input.
9. Adjust the potentiometer, located on the four-lug terminal strip near the range switch (inside the recorder), for 100% $\pm$0.5% pen deflection.
10. Check all inputs for proper inputs at 100% $\pm$0.5% pen deflection. Check zero for all ranges, as required.

5.3 TROUBLESHOOTING (See Table 5-1)

The troubleshooting information is included to serve as a guide to enable equipment repair. Likewise, the troubleshooting section is a guide only and cannot cover all possible contingencies that may occur.

TABLE 5-1
TROUBLESHOOTING CHART

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Pilot light does Not light; recorder is inactive	1. No ac power	1. Connect ac power source.
	2. Blown fuse	2. Replace fuse
	3. Conversion switch in wrong position	3. Check switch position.
2. Pilot light is on, but recorder is inactive	1. Disconnected signal input leads	1. Check the input connections.
	2. Loose preamp/servo driver circuit board	2. Tighten the circuit board connection.
	3. Gain set too low	3. Increase GAIN
	4. Defective preamp/ servo driver circuit board	4. Replace the circuit board.
	5. Defective servo motor	5. Replace servo motor

TABLE 5-1 (Continued)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
3. Excessive Deadband	1. Gain set too low	1. Increase GAIN.
	2. Excessive common mode signal	2. Connect the ground terminal to the source of the common mode signal.
	3. Recorder ground not connected to signal source ground	3. Provide a common ground for third wire (green or green and yellow) in the power cord.
	4. Loose pen drive cable	4. Tighten pen drive cable.
4. Noise on pen trace	1. Noisy input signal from signal source.	1. Check the signal source.
	2. Extremely noisy power line	2. Check the power line.
	3. Gain set too high	3. Decrease GAIN.
	4. Unconnected recorder ground	4. Provide a common ground for third wire (green or green and yellow) in the power cord.

TABLE 5-1 (Continued)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
5. Pen trace has isolated steps	1. Dirty pen carriage slide rod	1. Clean slide rod.
	2. Servo driver gain set too low	2. Increase GAIN.
	3. Defective servo motor	3. Replace the servo motor.
	4. Defective servo potentiometer	4. Replace servo potentiometer.
6. Pens stop moving, but catch up if pushed	Defective bearing in servo motor	Replace servo motor.
7. Pen writes poorly	1. Depleted ink supply	1. Replace the pen.
	2. Dried-out pen tip	2. Revitalize pen by dipping it in water for a few seconds.
8. Inoperative chart drive	1. Loose or defective power connections to the stepper transformer	1. Repair the power connections.
	2. Defective chart drive motor	2. Replace chart drive motor.

TABLE 5-1 (Continued)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
8. Inoperative chart drive (Continued)	3. Defective stepper chart drive PC board connections	3. Repair connections to the PC board
9. Continuous chart drive	Defective capacitor across chart ON-OFF switch	Replace the capacitor.
10. No chart drive in a particular chart speed	1. Loose or defective connections at chart speed selector or circuit board connector	1. Repair connections.
	2. Defective component on pc board	2. Replace the PC board.

SECTION 6 SPECIFICATIONS

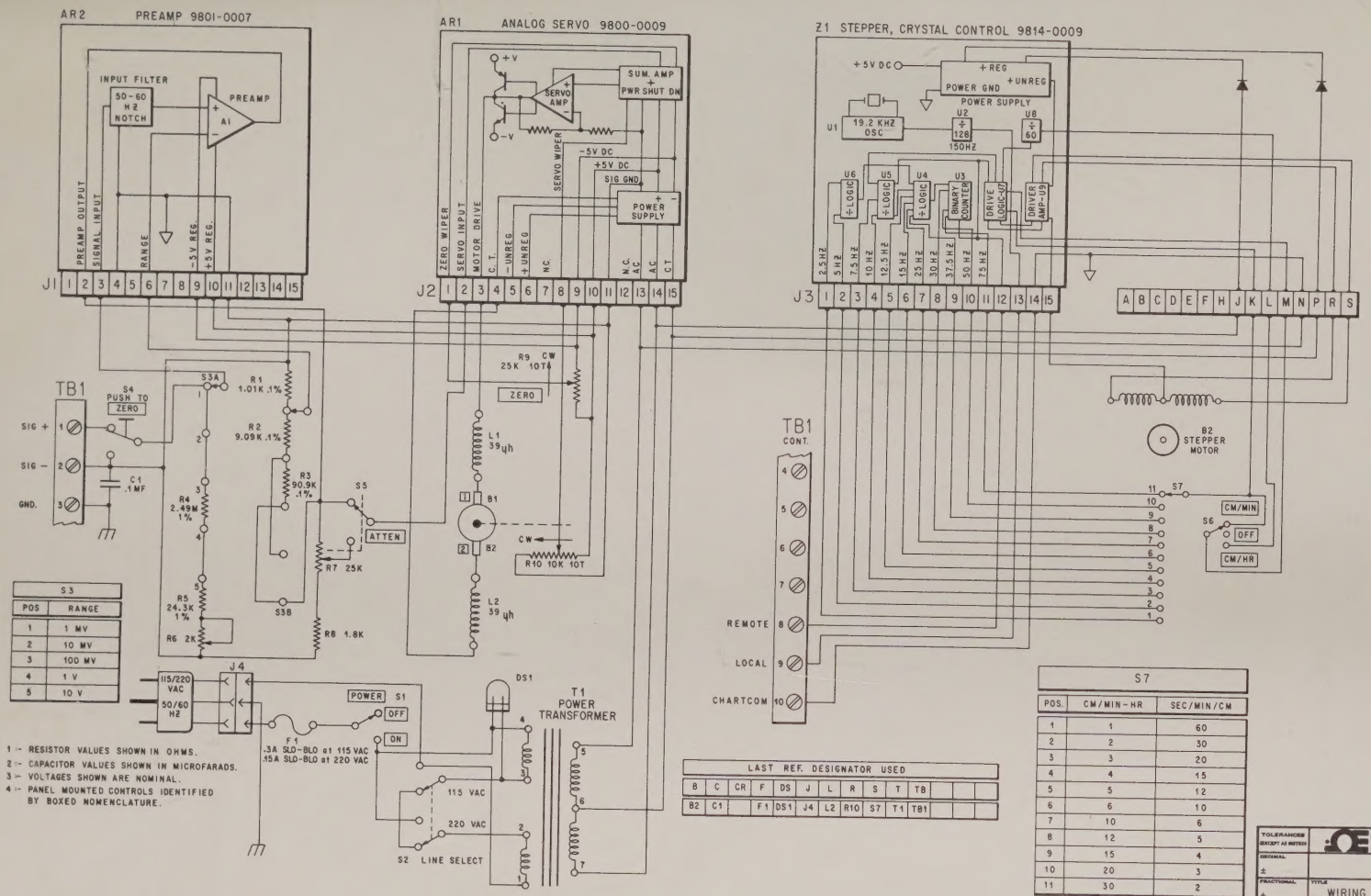
NUMBER OF CHANNELS:	One
WRITING METHOD:	Disposable fiber tipped pen
CHART WIDTH:	125 mm
CHART DRIVE:	Two-phase, stepper motor
CHART SPEED:	Selectable: 1, 2, 3, 4, 5, 6, 10, 12, 15, 20 or 30-cm/min. or cm/hr.

SPECIFICATIONS continued

POWER:	115/230 V ac; 50 or 60 Hz; 12 W
ACCURACY:	Deadband: ±0.3% Linearity: ±0.5% Repeatability: ±0.1%
RESPONSE TIME:	Less than 0.5-seconds, full scale
POWER SHUTDOWN TIME:	Approximately six seconds with ±overrange signal
FULL SCALE SPAN:	Selectable settings at 1 mV, 10 mV, 100 mV, 1 V, 10 V; attenuated to 100 V (uncalibrated)
ZERO ADJUST:	Continuous from -100% to 100%
OVERSHOOT:	None; system critically dampened
ZERO SHIFT TEMPCO:	Less than 0.05%/°C
INPUT TYPE:	Floating to ±100 V, single-ended
INPUT IMPEDANCE:	2.5 Megohm, fixed
SOURCE IMPEDANCE:	Greater than 50 kilohms will degrade specifications
DIMENSIONS:	H: 4.75" (120 mm) x W: 9" (228 mm) x D:11.5" (292 mm)
WEIGHT:	7.5 lbs (3.4 kg)

6.1 AVAILABLE ACCESSORIES AND SPARE PARTS

PART NUMBER	COMPONENT
0100-0017	CHART PAPER, 125-m
0100-0028	CHART PAPER, Z-fold
0100-0101	DISPOSABLE PEN, Blue, round
0100-0102	DISPOSABLE PEN, Red, round
0100-0103	DISPOSABLE PEN, Black, round
0100-0104	DISPOSABLE PEN, Green, round
5120-0006	FUSE, Slo-Blo, 0.3-A
5120-0007	FUSE, Slo-Blo, 0.15-A
6040-0005	CORD, Power (standard model)
6040-0006	CORD, Power (international model)
4750-0037	POTENTIOMETER (Servo, rebalance potentiometer)
3510-0007	MOTOR, Servo
3525-0002	STEPPER MOTOR, Chart
9001-0385	SPRING, Pen Carriage
9001-0010	CARRIAGE, Pen
9800-0009	PCB ASSEMBLY, Servo
9801-0007	PCB ASSEMBLY, Pre-amp
9814-0009	PCB ASSEMBLY, Stepper chart drive



LAST REF. DESIGNATOR USED													
B	C	CR	F	DS	J	L	R	S	T	TB			
B2	C1		F1	DS1	J4	L2	R10	S7	T1	TB1			

S7		
POS.	CM/MIN-HR	SEC/MIN/CM
1	1	60
2	2	30
3	3	20
4	4	15
5	5	12
6	6	10
7	10	6
8	12	5
9	15	4
10	20	3
11	30	2

OMEGA ENGINEERING, INC. Stamford, Conn. 06907

TOLERANCES (EXCEPT AS NOTED): DECIMAL ± ; FRACTIONAL ± ; ANGULAR ±

SCALE

DRAWN BY D.R.J.

APPROVED BY

TITLE: WIRING DIAGRAM - MODEL 156 RECORDER

DATE 6-8-83

DRAWING NUMBER D033-0090

REV.

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2. Model and Serial numbers.
3. Repair instructions.

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